

THE HONG KONG JOCKEY CLUB SERIES

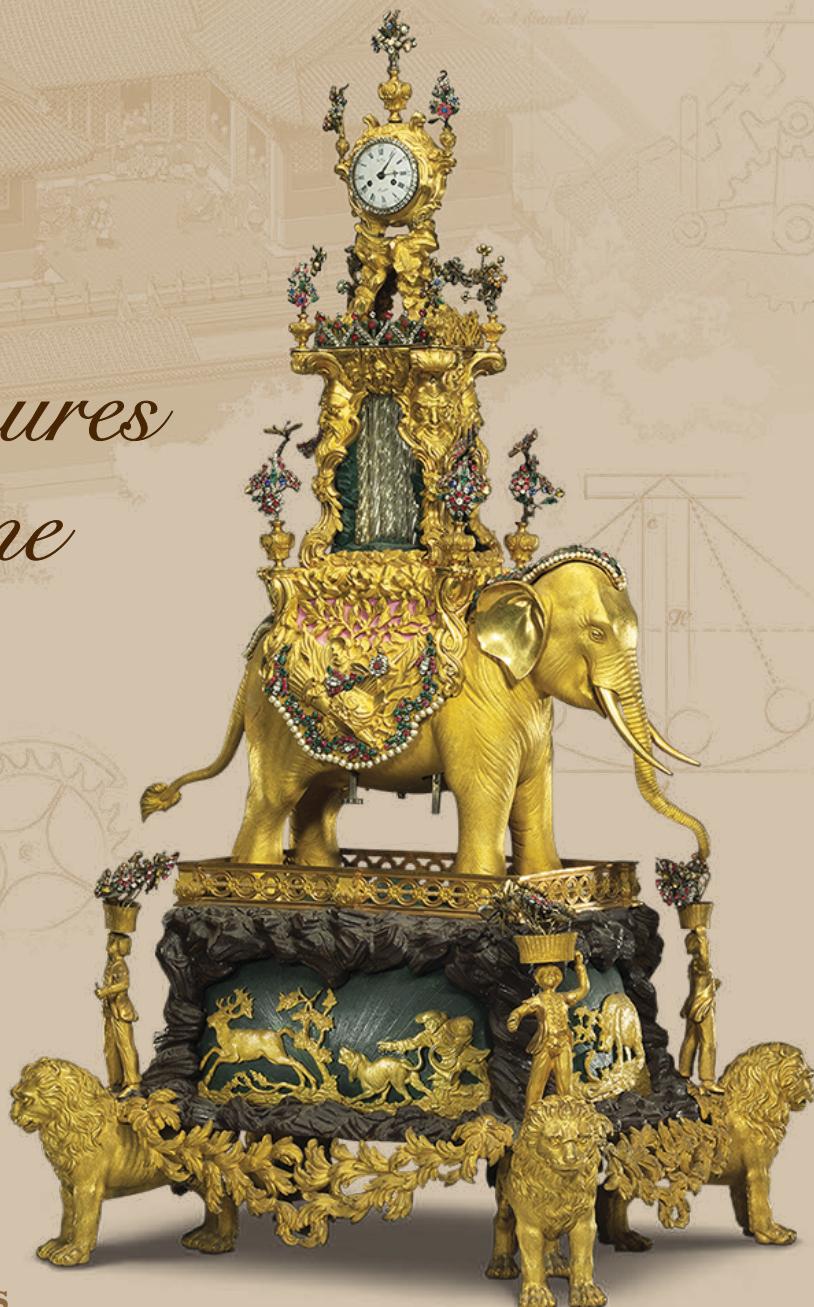
香港賽馬會呈獻系列

7.12.2018 - 10.4.2019

匠心獨運 *Treasures of Time*  
鐘錶珍寶展

趣味習作  
Activity Sheet

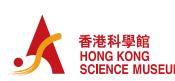
中學學生適用  
For secondary students



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作為一個鐘錶匠，必須要對鐘錶內的科學原理有所認識。你的師父為你準備了筆記，但有些部分未完成，你可以把它們完成嗎？

You need a thorough understanding of the scientific concepts related to clocks and watches in order to be a great clockmaker. Your master has prepared some notes for you. Can you complete it?

## 1. 齒輪組 Gear Train

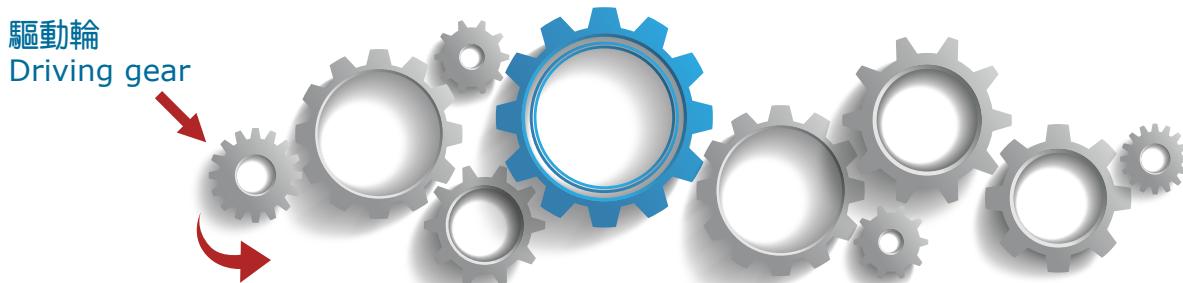
**齒輪比**是齒輪轉動速度的比率，亦恰好等於兩齒輪齒數的比例，把一個40齒的齒輪連接並帶動一個20齒的齒輪轉動，此齒輪組的比例側為 2:1，即大齒輪轉動一周，小齒輪已轉動兩周。

**Gear ratio** is the ratio of the rotation speed between gears. It is the same as the ratio of the number of teeth of the gears. Using a 40-toothed gear to drive a 20-toothed gear produces a gear ratio of 2:1. This means when the large gear has rotated once, the small gear has already rotated twice.

齒輪比可由以下數式計算：

The formula for gear ratio is as follow:

$$\text{齒輪比 Gear Ratio} = \frac{\text{驅動輪齒數 Number of teeth on driving gear}}{\text{受動輪齒數 Number of teeth on driven gear}}$$



16齒的驅動輪以每分鐘12圈的速度逆時針轉動，試計算藍色齒輪的轉速及找出它的轉動方向。

The 16-toothed driving gear is rotating anti-clockwise with a speed of 12 revolutions per minute. What is the speed and rotation direction of the blue gear?

藍色齒輪的齒數 No. of teeth of the blue gear: \_\_\_\_\_

藍色齒輪的轉速 The speed of the blue gear: \_\_\_\_\_

藍色齒輪的轉動方向 The rotation direction of the blue gear: \_\_\_\_\_

我們知道一分鐘有60秒，所以分針齒輪的轉速必須是秒針齒輪的 $\frac{1}{60}$ 。用以下哪些齒輪可以建立一組齒數比是1:60的齒輪組？試計算一下。

We know that every minute has 60 seconds. Therefore the rotation speed of the gear of minute hand has to be  $\frac{1}{60}$  of that of the gear of second hand. Using which of the following gears can you construct a gear train with gear ratio 1:60? Try to work it out.

6齒、8齒、16齒、24齒、40齒及60齒

6-toothed, 8-toothed, 16-toothed, 24-toothed, 40-toothed and 60-toothed

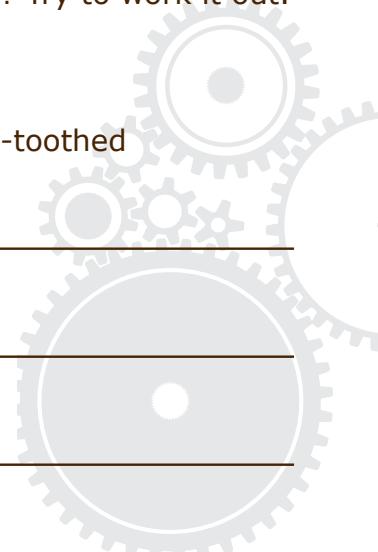
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試想想...

Think about it...

一般鐘錶都是以12小時作錶面，有想過用24小時嗎？控制時、分及秒針的齒輪又應是甚麼比例？

Usually, clocks and watches display 12 hours only. Ever thought of having clocks and watches displaying 24 hours? What should the gear ratios of the hour hand, minute hand and second hand be in order to achieve this?

## 2. 鐘擺的科學

### Pendulum Science

機械鐘可透過鐘擺調整擒縱器的節拍。周期 (**T**) 是指鐘擺來回擺動一次所需的時間。根據以下方程，我們可以計算出鐘擺的周期，當中 **l** 為鐘擺的長度，**g** 為重力常數。

A pendulum helps regulate the rhythm of the escapement of a mechanical clock. The time needed for a pendulum to complete one to and fro motion is called period (**T**). The period can be calculated from this formula, where **l** is the length of the pendulum and **g** is the gravitational constant.

$$T = 2\pi \sqrt{\frac{l}{g}}$$

一單擺以周期 1 秒擺動，它的長度是多少？(以  $\pi = 3.14$  及  $g = 9.81 \text{ ms}^{-2}$  計算)

A simple pendulum swings with a period of 1 second. What is its length?  
(Take  $\pi = 3.14$  and  $g = 9.81 \text{ ms}^{-2}$ )

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試想想...  
Think about it...

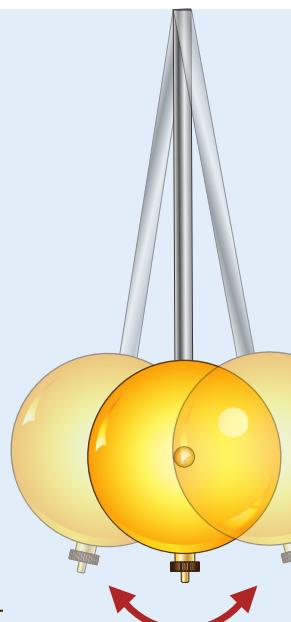
甲擺鐘以 25 厘米鐘擺連接 500 克的鐘錘，乙擺鐘以 25 厘米鐘擺連接 250 克的鐘錘，你認為哪一台擺鐘有較高的擺動頻率？為甚麼？

Pendulum clock A has a weight of 500g attached to a 25cm rod and pendulum clock B has a weight of 250g attached to a 25cm rod. Which one has a higher frequency? Why?

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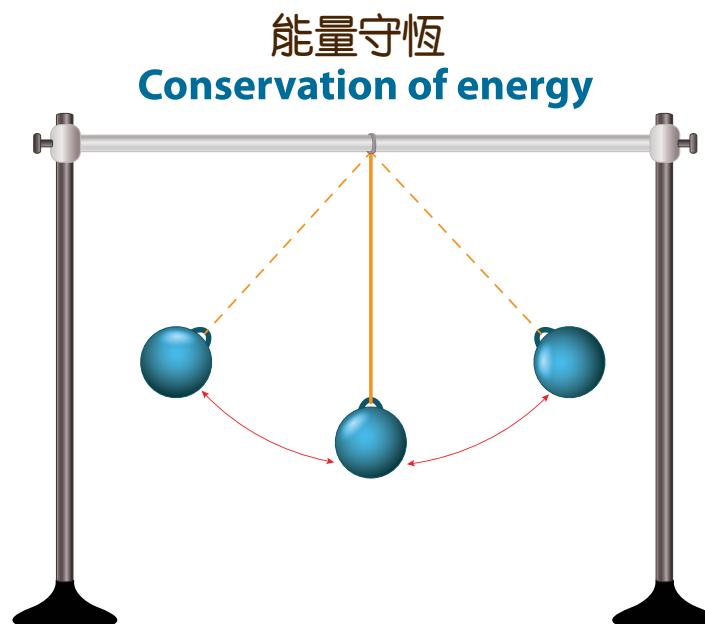


當鐘錘擺至最高點時，其所有**勢能 / 動能**會轉換為**勢能 / 動能**。

When the bob of the pendulum has reached the highest position, all its **potential / kinetic** energy is converted to **potential / kinetic** energy.

當鐘錘擺至最低點時，其所有**勢能 / 動能**會轉換為**勢能 / 動能**。

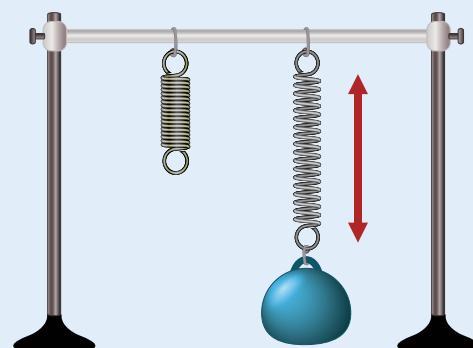
When the bob of the pendulum has reached the lowest position, all its **potential / kinetic** energy is converted to **potential / kinetic** energy.



知多一點點：  
More to learn:

當鐘擺擺動的時候，鐘錘的擺動會趨向平衡位置，而施於鐘錘的力是與位移成正比及相反方向，這稱為**簡諧運動**。在彈簧上來回彈動的質量是另一例子。

When the pendulum bob is set in motion, it always tends to swing back to its equilibrium position. The force applied to it is in the opposite direction and proportional to the displacement. This type of motion is known as **simple harmonic motion**. Another example is the bouncing of a mass on a spring.



### 3. 鐘錶裏的化學物質

### Chemicals in Clocks and Watches

以下文字寫出三種用於鐘錶的化學物質的特性，試在空格填上答案。

The descriptions below are about three chemicals used in different kinds of clocks and watches. Do you know the properties of these chemicals? Fill in the blanks below.



石英是一種由 \_\_\_\_\_ 和 \_\_\_\_\_ 原子以連續的共價鍵組成的礦物。電流通過石英晶體時會產生穩定的振動電場，這現象稱為 \_\_\_\_\_  
\_\_\_\_\_.

Quartz is a mineral composed of \_\_\_\_\_ and \_\_\_\_\_ atoms covalently bonded in a continuous structure. A steadily vibrating electric field will be produced when current passes through a quartz crystal. This phenomenon is known as \_\_\_\_\_  
\_\_\_\_\_.

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Cs

Caesium

銫是一種銀金色的 \_\_\_\_\_，其熔點極低，所以在室溫或接近室溫下為 \_\_\_\_\_. 銫金屬非常活躍，即使於攝氏零下110度也能與水產生化學作用。

Caesium is a silvery-gold \_\_\_\_\_ with a very low melting point. It is in \_\_\_\_\_ state at or near room temperature. It is the most reactive metal that reacts with water even below -110°C.

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Rb

Rubidium

鉭是一種銀白色的金屬，其活躍程度比銫金屬較 \_\_\_\_\_. 由於鉭金屬在地殼中的存量比銫更豐富，以它製作的 \_\_\_\_\_ 比用銫所造的成本低。

Rubidium is a silvery-white metal which is \_\_\_\_\_ reactive than caesium. Because rubidium exists in greater abundance in earth crust, it is less expensive than caesium in the production of \_\_\_\_\_.

## 4. 歷代比較

### Comparison between Generations

計時儀器不斷進步，你對以下的鐘錶認識有多少？根據你的知識及後頁的資料，試比較它們並填上有關資料。

Timekeeping instruments are evolving. Can you compare the following instruments based on your understanding and the information on the next page?

A



原子鐘  
Atomic clock

B



石英鐘錶  
Quartz clock and watch

C



機械鐘  
Mechanical clock

最精確 The most accurate : \_\_\_\_\_

最方便攜帶外出 The most convenient to be carried out : \_\_\_\_\_

動力來源 The power source :

A \_\_\_\_\_

B \_\_\_\_\_

C \_\_\_\_\_



電流通過石英晶體時會產生穩定的振動電場，石英鐘錶一般以32.768千赫為振動頻率標準。這種鐘錶每十年會出現約一秒誤差。

A steadily vibrating electric field will be produced when current passes through a quartz crystal. Quartz clocks adopt 32.768 kHz as the oscillation frequency standard. They are accurate to about one second in ten years.

原子鐘以原子振盪來計時。銫原子鐘內的原子每秒振盪超過90億周。原子的振盪周期不會受外間條件(如溫度)影響。

Atomic clocks keep time by the vibrations of the atoms. A caesium atomic clock has its atoms vibrating at over 9 billion cycles a second. The vibration period of the atoms is unaffected by external conditions like temperature.

機械鐘以重力推動的鐘擺作動力來源，最好的機械鐘每年行走快或慢四秒。

Mechanical clocks keep time by the oscillation of weight-driven pendulums. The best mechanical timepieces gain or lose about four seconds a year.

## 5. 數學挑戰題

### Maths Challenge

除了鐘錶的運作，時間的概念對鐘錶匠也是很重要的。你可以解答以下有關時間的題目嗎？

Other than the operation of clocks and watches, the concept of time is also important to a clockmaker. Can you solve the following questions about time?

1. 五時正以後的甚麼時候，時針和分針在「6」的兩邊而離「6」的角度相等？

After 5 o'clock, when will the hour hand and minute hand "6", and make the same angle with and lie on the two sides of "6"?

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2. 一個法國送來的鬧鐘每小時快四分鐘。晚上10時30分的時候，你把鬧鐘與香港天文台標準時間對準，同時把鬧鐘設定至早上5時50分響鬧，聽到鬧鐘響聲時比香港標準時間早多少？

An alarm clock from France runs 4 minutes faster every hour. At 10:30pm, you reset the alarm against the standard time of the Hong Kong Observatory, and set the alarm at 5:50am. How many minutes earlier than Hong Kong standard time will you hear the alarm ring?

- A. 25.5分鐘minutes   B. 27.5分鐘minutes   C. 29.5分鐘minutes   D. 31.5分鐘minutes

